Forest Sciences

Prince Rupert Forest Region

Extension Note # 18
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Floodplain Erosion Hazard Mapping
Zymoetz (Copper) River, Terrace, B.C.

Research Issue Groups:

Forest Biology

Forest Growth

Soils

Wildlife Habitat

Silviculture

Ecosystem Inventory and Classification

Biodiversity

Ecosystem Management

Hydrology

Geomorphology

Extension

Background

Large rivers within an unconfined valley typically have a floodplain. Flooding of the low flat surface adjacent to rivers often occurs with periodic or episodic high flows. The surface of the floodplain is constructed by the river; a result of fast flowing currents eroding banks, and at another location downstream, overbank flooding and subsequent deposition of sand silts and gravel. A network of flood channels (back channels and side channels), connected to or cut off (dormant channels) from the main river channel, cover the floodplain surface. Dormant channels are frequently revegetated or forested.

The flat terrain adjacent to rivers was, until recently, often used by forest developers for road location. While original construction was easy and fast, time and money had to be spent later on flood damage repair works. Bank erosion potential and flood damage were often underestimated, particularly on the heavily forested part of a floodplain and on sites that may have appeared

Figure 1. Gravel-bed character of the Zymoetz River, near kilometer 29.

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Figure 2. Clore River confluence. During the 1978 flood, 300 metres of the Copper River Road were eroded (between point A and B).

to be a safe distance from the main channel.

Wandering Gravel-Bed Channel

A wandering gravel-bed river exhibits an irregular pattern of channel instability: haphazard meander bends, many flow branches, a main channel and side channels separated by gravel bars and forested islands and sinuous back channels (old channels) that bypass several meander bends. These channel features are evident in many rivers of northwest British Columbia that contain highly mobile bed sediments.

In wandering gravel-bed rivers, a rapid channel shift during flood flows from a main channel into side channels or into "dormant" old back channels can move the main channel by several hundred metres within days. This type of channel shift or **channel avulsion** frequently occupies older channels. Forested islands are old floodplain surface remnants isolated by channel avulsion.

Lower Zymoetz River Valley

Several sections along the lower 50 km of the Zymoetz River form a wandering gravel-bed river. Particularly "wild" are the reaches between road km 25 and 45, upstream and downstream of the Clore River junction.

In the early 1960's, the Copper River Forest Road was built. The road followed the south side of the river for 50 kilometres and ended north of Limonite Creek. Long sections of the road were built on the floodplain. In the early 1970's, the natural gas pipe line from Smithers to Terrace through the Telkwa Pass was also routed along the lower Zymoetz River. In November 1978, a 100-year flood eroded many sections of the road and the pipeline; some sections were abandoned, others rebuilt. Repeated flooding in 1988, 1991 and 1992 damaged and eroded many of the rebuilt road sections. What had been considered a "stable" road location for the first 15 years, now seemed to have become a chronic and expensive problem, demanding a long-term solution.

Channel Geomorphology

Air photo interpretation and GIS mapping of the channel configuration since 1949 showed that the channel dynamics changed with the flood in 1978. Upstream of the Clore River junction, bank erosion rate increased 800 % during the 1978 and several smaller subsequent floods. Where the river had been flowing in a single-thread, sinuous channel, it became a wide, straight chute with large gravel bars separating several channels. At the Clore River junction, a long meander bend was abandoned. The new channel took on a straight course and eroded a gravel terrace and road for several hundred metres. A large amount of gravel entered the channel during the 1978 flood from previously forested channel banks and terraces. With every flood, highly mobile bedload pulsed down-channel, pushing the channel further into the floodplain, gravel terraces and scarp slopes.

During the floods in October 1991 and 1992, a channel avulsion cut through the Zymoetz floodplain near the Kitnayakwa River junction. This avulsion was in response to gravel

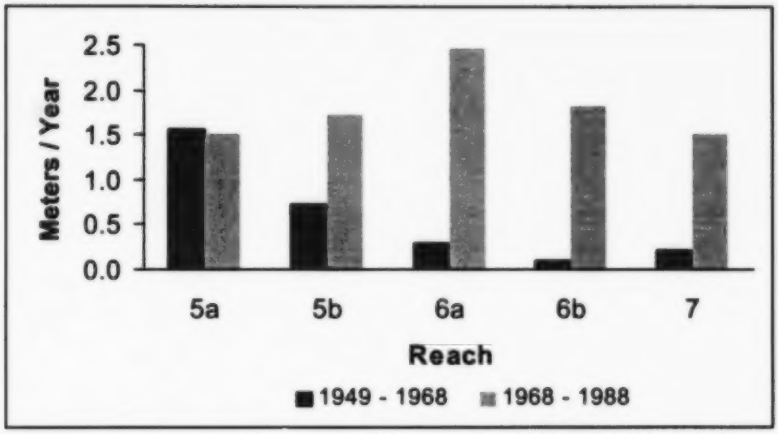

Figure 3. Mean annual bank erosion rate upstream (reaches 5b, 6a&b and 7) and downstream (5a) of the Clore River confluence before and after the 1978 flood.

in-filling of the old channel bed; up stream, bank undercutting had destabilized an 80 metre tall scarp slope and mobilized a large amount of gravel. Vertical and lateral channel adjustment is now taking place at the site, as the river seeks to re-establish a stable channel configuration in response to the increased sediment supply and steeper channel gradient.

Extreme Fall Rainstorms and Floods

The hydrologic regime of many rivers in the Terrace area is governed by rainfall induced autumn floods of short-duration high peak flows. Evaluation of discharge data for the Zymoetz River reveals an increased flood frequency from the mid-1970's to the mid-1990's. Five severe floods (larger than a 10-year flood) occurred in the 20 years between 1974 and 1994. Between 1952 and 1973, floods were smaller and only one 10-year flood occurred.

All five severe floods (1974, 1978, 1988, 1991, 1992) were in response to heavy rainstorms (> 70 mm rain in 24 hours) combined with "warm" temperatures throughout or towards the end of the rainstorm. Smaller "warm" rainstorms following wet antecedent conditions also caused flooding. A large but "cold" rainstorm in 1990 with over 100 mm of rain in 24 hours did not cause any flooding in the Zymoetz River. A two to five degree Celsius temperature difference between "warm" and "cold" rainstorms leads disproportionally to a large run-off.

This can be explained with the elevation geometry in the Zymoetz River watershed. While elevation ranges from 250 metres to 3,000 metres above sea level (ASL), 60 % of the area is situated between 900 and 1500 metres. During a "cold" storm, freezing levels are near the 900 metre mark and precipitation falls as snow over most of the watershed; during "warm" storms, freezing levels are near 1500 metres ASL and rain falls over 60 % of the watershed area. Long-term climate data indicated that such flood-prone weather occurred less frequently between 1913 and 1973 compared to the years 1974 to 1993. A relatively stable channel configuration evident on 1939 and 1949 air photographs corroborates this finding that flooding and channel shifting were less severe prior to 1974.

Road and Pipeline Location Compound the Problem

Flood waters commonly flow into existing side or back channels. During the 1978 flood, several 100 metres of road at km 40, upstream of the Clore River junction, acted in a similar manner as a side or back channel: the road provided a straight, cleared and easily erodible new channel location. The road right of way was rapidly scoured generating a large amount of bedload. Much of this material was transported downstream in the form of a gravel wedge; triggering more bank erosion, channel widening and further channel avulsion downstream.

Near road km 38, rip-rap bank protection was placed along the channel to secure the pipeline location. This has kept the channel in the straight flume created by the 1978 flood and has prevented adjustment of the channel gradient to a more sinuous channel configuration. Bedload storage capacity in the reach was reduced and gravel accumulation downstream of the reach increased; at road km 35.5, gravel in-filling and raising of the channel bed is

Figure 4. Rapid gravel bar accumulation and channel avulsion at the Kitnayakwa River confluence occurred during the floods in 1991. The pre-1991 channel along the very outside of the meander bend is now filled-in with gravel and sand.

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beginning to set the stage for more rapid and unpredictable channel change (a possible avulsion at the Clore River junction).

Management Implications

We have prepared a floodplain erosion hazard map for the lower Zymoetz River floodplain. The map shows areas exposed to streambank erosion and sites of possible channel changes in the near future. The floodplain erosion hazard map can assist engineers/planners in the relocation of the existing road onto less erosion-prone sites. Given the present state of channel dis-equilibrium, channel adjustments will continue for several years. Locally, streambank erosion may accelerate. Any design of streambank protection must consider potential downstream impacts. New development, channel restoration or habitat enhancement projects on the floodplain must take into account the highly dynamic fluvial regime of the lower Zymoetz River.

Fluvial Geomorphology Research

Gravel-bed rivers in the Prince Rupert Forest Region are undergoing channel readjustment Some rivers are situated in watersheds that have been affected by various land uses and others are in undisturbed watersheds. Research is required to understand the geomorphological variability of the rivers, climatalogical effects on floods, and land use impacts on the fluvial systems.

Suggested Reading

Weiland, I. and Schwab, J. 1996. Floodplain Erosion Hazard Assessment, Lower Zymoetz River, Terrace, B.C. Preliminary Report, Forest Sciences Section, Prince Rupert Forest Region, Ministry of Forests, Smithers, B.C.